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Display and analysis of electrophysiological data under Windows^{TM}

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Introduction

Insect electrophysiologists benefit from the work of a number of programmers who have designed appropriate programs to record and analyse extracellular recordings. These programs were developed for different hardware and software environments, ranging from mainframe computers (Frazier & Hanson, 1986) to PC DOS computers (Marion-Poll & Tobin, 1991; Smith et al., 1990), Macintosh® (P. Roessingh, R. Baur, A. Fritschy & E. Städler, unpubl.) or even Atari computers (by Gödde in Hansen-Delkeskamp, 1992). These programs addressed the same questions but used slightly different algorithms, different data file structures, different programming languages (BASIC, FORTRAN, PASCAL, C) and incompatible binary code.

We have developed a program running under Windows for the display and analysis of electrophysiological recordings from insects. This program, AWAVE, manipulates data acquisition files obtained from two different data acquisition programs. Flexible data display printing and spike analysis are implemented. It can export various data under ASCII format to the clipboard and to spreadsheet programs. The object-oriented design of the program and its flexibility makes it well-suited for adaptation to various needs on different platforms. The use of this program is illustrated by the analysis of recordings from taste hairs stimulated both by salts and mechanical bending of the hair shaft.

Materials and methods

In our laboratory, data are acquired on two electrophysiological set-ups that generate different file formats. The first set-up is used to record from taste receptors on a PC running a custom FORTRAN program, ATLSPK (Marion-Poll & Tobin, 1991). ATLSPK drives the data acquisition (DT2821 board, Data Translation, USA) and the amplifier parameters (gain and filter settings; CyberAmp 320, Axon Instruments, USA). It provides oscilloscope-like display, data acquisition and file saving. The second set-up is used to perform extracellular recordings from olfactory receptors. It uses a DASH-16 board (Keithley, USA) and runs custom programs developed by M. Renou under ASYST.

Sample recordings were obtained from taste receptors using a TastePROBE amplifier (Marion-Poll & van der Pers, this volume). Tarsal sensilla receptors from adult *Ostrinia nubilalis* Hübn. (Lepidoptera, Pyralidae) were stimulated with a 0.1 M KCl solution. In order to stimulate the mechanoreceptors at the base of these hairs, the recording electrode was repeatedly moved by hand to bend the hair shaft. The initial contact with the hair triggered the acquisition. Data were recorded during 8 s and sampled at 10 kHz using ATLSPK.

AWAVE was developed on a compatible PC using Visual C^{++} (Microsoft, USA). This program is based on standard objects from Microsoft Foundation Classes (MFC). It is optimised for fast display on computers running under Windows (Marion-Poll, 1995).

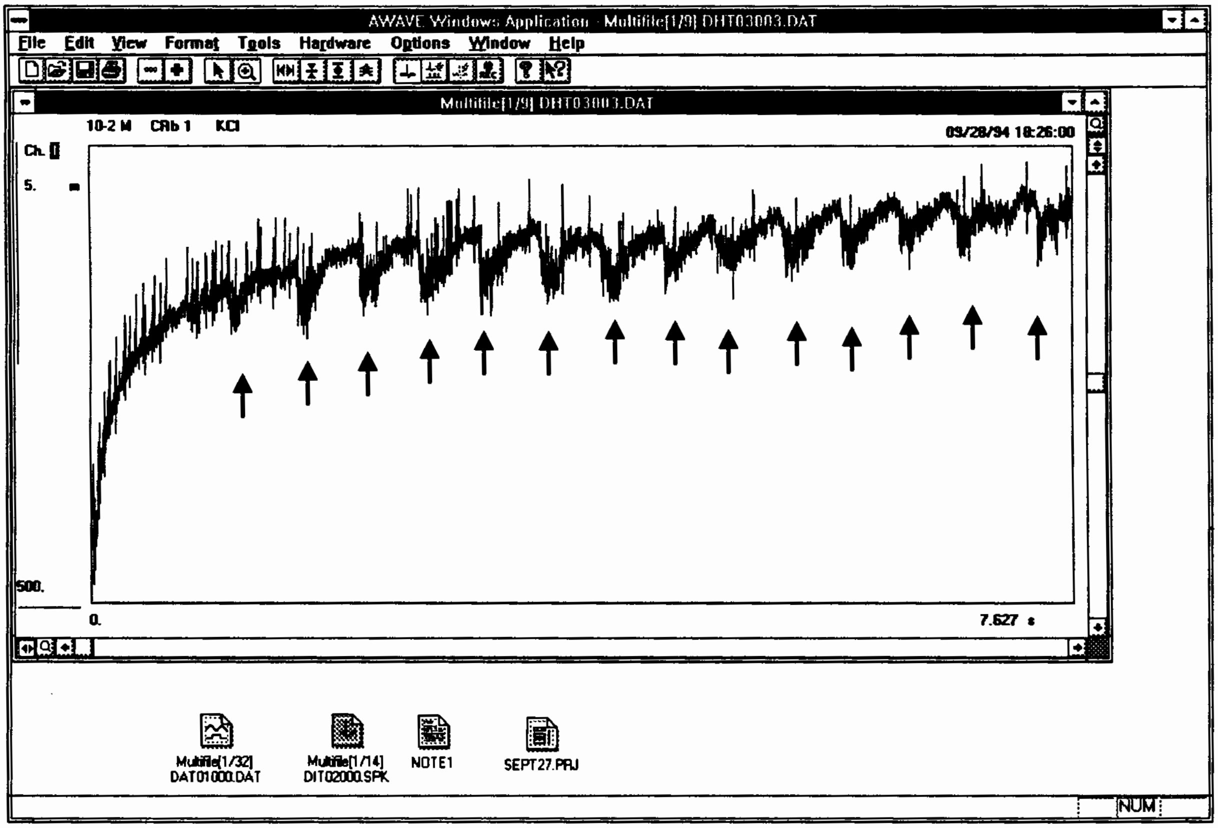

Figure 1. Recording from a taste receptor manually bent (arrows) to stimulate its mechanoreceptor. Nine recordings were made under the same conditions. They are loaded at once within a multi-file document. AWAVE can load simultaneously data files (DAT), spike files (SPK), text files (TXT) and project files (containing a list of files PRJ).

Analysis of electrophysiological data

Electrophysiological records are analysed in consecutive phases: data inspection either on the screen or on a printer (Figure 1), spike detection (Figure 2), spike sorting by wave-form criteria (Figure 3) and time series analysis. It should be stressed that electrophysiological experiments generate a host of files. Typically, one recording session yields 20 to 100 files and hence a complete experiment may give rise to thousands of files. All of these files have to be manipulated in order to extract information from them. The results from such analyses are transferred to a spreadsheet (Excel 5: Microsoft) to facilitate the large database manipulation tasks.

Data display

An essential feature of AWAVE is the possibility of manipulating a list of data files within a single document rather than one by one. Once a file or a series of files is selected by the user, the program display the selected data (Figure 1). Browsing from file to file is accessed by clicking on toolbar buttons or via menu items. Display settings are adjusted automatically or via mouse actions, buttons and scrollbars and menu items.

Data acquisition files from two formats are read transparently (ATLSPK and ASYST types). We are currently developing routines to read data files under PC-Clamp format. The program provides most of the functions needed to display data interactively, to generate printouts of any scale and to export displayed curves to other programs. Special-purpose algorithms achieve fast display even with long recordings (Marion-Poll, 1995). Figure 1 shows the first of nine selected files.

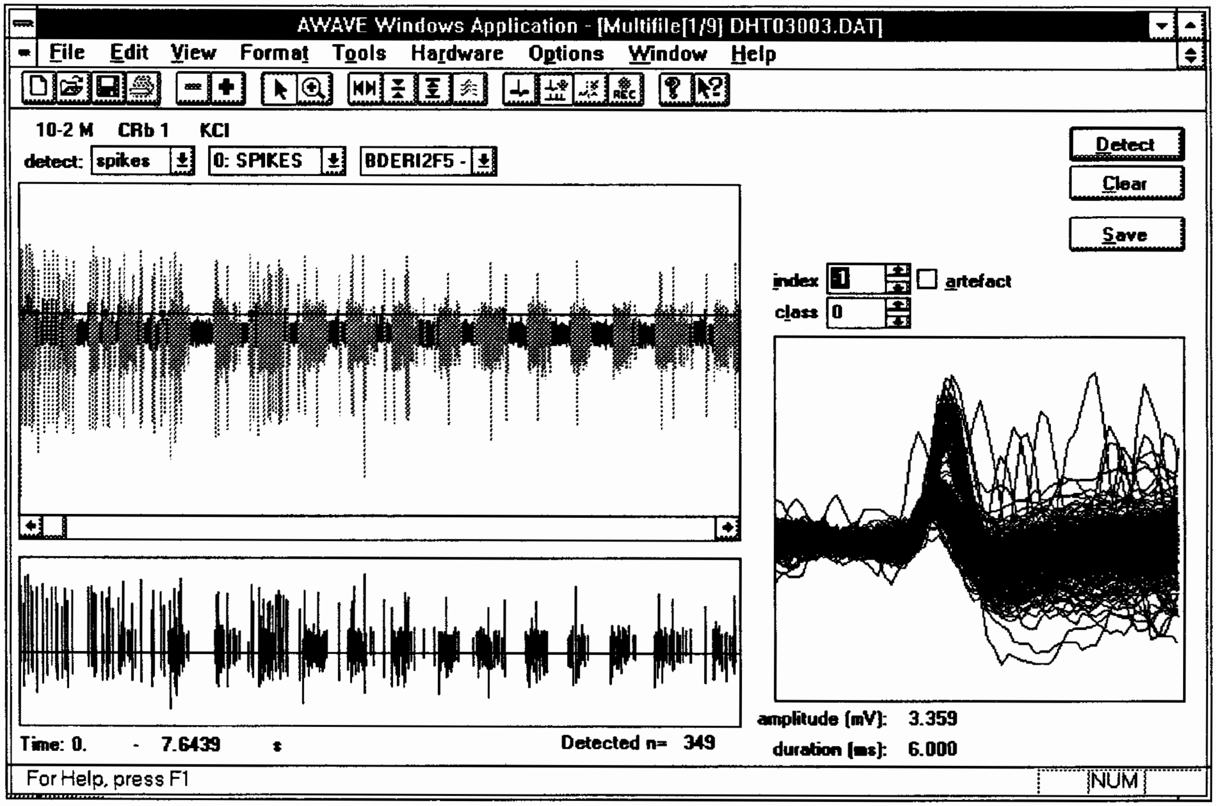

Figure 2. Spike detection from the sample record. Spike detection is performed by threshold comparison after digital filtering to remove baseline variations. When a threshold crossing is found, 60 points from the original data are stored together with the time into a spike file. The spikes detected in this record are displayed (1) marked on the original signal, (2) as bars and (3) superimposed. All parameters needed to perform these operations can be selected manually.

After the initial contact, a burst of action potentials is elicited each time the hair is bent (arrows). Spike detection and sorting allows us to discriminate between these spikes and those originating from chemosensitive receptor-neurons.

Spike detection and sorting

Spikes are detected by comparing an adjustable threshold either to the original or to a filtered image of that signal (digital high pass filter) (Marion-Poll & Tobin, 1991). Whenever the transformed signal crosses the threshold, a series of points from the original signal is stored together with the time. From these samples, AWAVE generates spike files to store the information. Figure 2 shows the spikes detected from the first file of the series. The threshold level was adjusted by the mouse after selecting the proper data transformation. Each detected spike (lower or left rectangle) can be individually selected and edited.

Spike sorting is performed on spike files accessed either individually or in groups. We currently separate spikes into classes on the basis of parameters measured from the original data (Figure 3). AWAVE exports spike data to the clipboard either as the number of occurrences during consecutive time bins, as time intervals or as values of the amplitude extremes. In the sample recordings, this analysis demonstrated that spikes elicited in response to hair-bending originated from the mechanoreceptor neuron. Mechanoreceptor spikes have a lower amplitude and are associated with a baseline deflection. These receptors are most likely to be stimulated during the first milliseconds after the initial contact. This study should be helpful in analysing responses from chemoreceptors within extracellular recordings by excluding the activity of the mechanoreceptor.

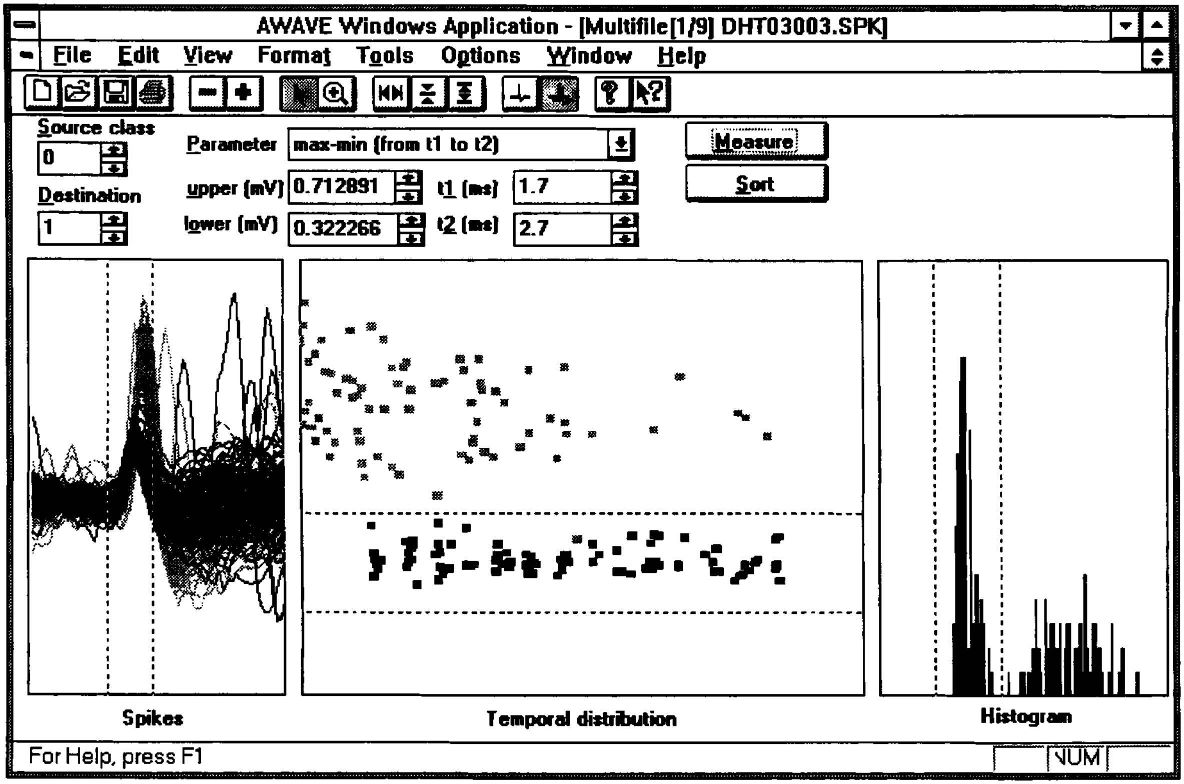

Figure 3. Spike sorting. If the spike wave-forms are separated into amplitude clusters, it becomes possible to separate spikes by adjusting thresholds as shown in this sample. On the screen, source spikes are plotted in black. On the left, these spikes are superimposed (1). Parameters measured on these spikes are displayed both as dots versus time (2) and as a histogram on the left (3).

Conclusion

Windows represents an attractive environment in which to implement a data analysis program. This environment benefits from a number of tools and programs that allow manipulation and analysis data interactively. Windows also has networking facilities that enable analysis of data from any microcomputer connected to the network. This approach leads to more efficient use of electrophysiological set-ups. Object-oriented development tools provide new opportunities to develop applications for neuroscientists and should facilitate sharing independently designed algorithms.

References

Frazier, J. & F. E. Hanson, 1986. Electrophysiological recording and analysis of insect chemosensory responses. In: J. R. Miller & T. A. Miller (eds), Insect-Plant Interactions. Springer-Verlag, New York: 285–330.

Hansen-Delkeskamp, E., 1992. Functional characterization of antennal contact chemoreceptors in the cockroach, *Periplaneta americana*. An electrophysiological investigation. Journal of Insect Physiology 38: 813–822.

Marion-Poll, F., 1995. Object-oriented approach to fast display of electrophysiological data under MS-Windows^{TM}. Journal of Neuroscience Methods 63: 197–204.

Marion-Poll, F. & T. R. Tobin, 1991. Software filter for detecting spikes superimposed on a fluctuating baseline. Journal of Neuroscience Methods 37: 1–6.

Smith, J. J. B., B. K. Mitchell, B. M. Rolseth, A. T. Whitehead, & P. J. Albert, 1990. SAPID Tools: microcomputer programs for analysis of multi-unit nerve recordings. Chemical Senses 15: 253–270.